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Kelulut honey-filled pots detection using image processing based techniques

Wan Nur Azhani W. Samsudin[1], Mohd Harizan Zul[2], Mohd Zamri Ibrahim[1], Rohana Abdul Karim[1]
[1]Computational System Intelligence, Faculty of Electrical and Electronic Engineering Technology, Universiti Malaysia Pahang, Malaysia
[2]Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang, Malaysia

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ABSTRACT

Kelulut bee is one of the stingless bee species in Malaysia, which is not dangerous to human. Honey from Kelulut bee can be used for the treatment of a variety of illness. The awareness of honey nutrition in our health makes it received high demands from the consumers. Traditionally, beekeepers did the manual inspection to check the honey-filled pots by using the straw or needle. The high demand from the consumers and the greater size of Kelulut beehive make it impractical to check manually all the honeypots which are time-consuming. The hygiene of the collected honey is also important to produce a good quality of honey. Hence, an automated honey-filled pots detection system is proposed to overcome these limitations. The proposed system will reduce the time consuming and less prone to error of the wrong estimation of honey-filled pots. MATLAB software is used to process the image of the Kelulut beehive which is challenging due to the overlapped honeypots in the image. Using the proposed algorithm, it can detect whether the pots filled with honey or not by using image processing techniques and it will analyse the image which represents the percentage amount of honey in the beehives.

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Corresponding Author:

Wan Nur Azhani W. Samsudin
Faculty of Electrical and Electronics Engineering Technology, Universiti Malaysia Pahang
26600 Pekan, Pahang, Malaysia
Email: nurazhani@ump.edu.my

1. INTRODUCTION

Stingless bees are one of the biggest group of bees, comprising the other type of bee such as tribe ‘Meliponine’ (sometimes called stingless honeybees) in the family ‘Apidae’. It is also known as Kelulut bee in Malaysia. The species of stingless bee have been found along years ago and closely related to the common honeybees, carpenter bees, orchid bees, and bumblebees. Stingless bees collect nectar, which then is stored in an extension of their gut called a crop. At the backof beehive, the bees ripen or dehydrate the nectar droplets by spinning them inside their mouthparts until the honey is formed. Ripening concentrates the nectar and increases the sugar content, though it is not nearly as concentrated as the honey from true honeybees.

Honey is a natural food extracted from the honey bee and commonly used as a sweetener. Besides, honey also is known for its remedial value [1]. Unlike a hive of commercial honeybees, which can produce 75 kilograms of honey a year, a hive of stingless bees produces less than one kilogram. Due to the low production of stingless bee honey [2], studies on the potential of honey in treating several health problems are mostly focusing on Manuka and Tualang honey compared to the stingless bee honey.

Kelulut bee produce a different taste honey which is a mix of sweet and sour taste, which is comes from plant resins of various flowers and trees, where the bees use to build their hives and honeypots [3]. The

color of the honey is usually clearer liquid [2].The studies proved that the stingless bee honey has great potential in modern medicine [2]-[6] and considered to have a higher medicinal value than other bee species [5]. The honey that is produced by stingless bees has the finest grade, high-quality honey and propolis products that are rich in anti-oxidants [7], [8], anti-microbial [9]-[13] and anti-inflammatory [14]. These honey and propolis are naturally suitable to cure illnesses through modern treatment methods such as diabetes mellitus, stroke, hepatitis, cancer [15], [16], hypertension, kidney stones, gout and cough. In terms of nutritional value and benefit, it is very much better than the normal honey.

Since Kelulut bee honey can be used for treating a variety of illness, recently it gets high demand among consumers. To assist the traditional way in detecting and extracting this honey, an automated system of Kelulut honey-filled pots detection is developed. Automated Kelulut honey-filled pots detection is the system to detect and recognize the honey-filled pots of stingless bee using image processing method, which is based on the color feature. The system able to detect honey-filled pots, without touching the beehives which considered the hygiene practices and good quality of the extracted honey.

2. RELATED WORKS

Honey is valuable extract which is economically and culturally around the world, The discussion of honey usually considering the honey bee. There a few of research areas which involve bee and beehives. Some of them investigated the behavior of the bee colony [17]-[19] and some of the research focuses on monitoring the health condition and activities of bee colony [20]-[22]. Most of the research involve the process of inspection using either by human visual or machine vision. Traditional way of detecting bee comb in a beehive by visual inspection become tedious when the inspector dealing with thousands of beehives. It is one of the drawbacks and the crucial is it needs a trained inspector to check the bee comb in a beehive. To overcome this limitation, a few systems have been developed which integrated with machine vision to replace the presence of human in the inspection process. It is become advantages to the beekeepers and researchers in the research area.

However, there are limited numbers of research works that focused on bee comb detection. Liew *et al*. [23] used circulation Hough Transformation (cHT) method to detect and count the number of cells in a bee comb. The finding of the works is more than 80% for detection rate, which is obtained from the counted cells using the proposed method compared with manual calculation. The others are concerned on monitoring bee behaviors, bee activities, bees' health condition and the effect of destructors to the beehive. There are two approaches applied to monitor bee colony health condition. The first is by monitoring individual bee, for example the queen by video-based image [20]-[25] or inspect bee brood frame for healthy brood area and healthy cell percentage [26]. Compared with the first approach, the second one costs less in terms of equipment and gives more information in terms of healthy cell numbers and percentages. In addition, the visual inspection is very time-consuming, tedious, and inaccurate due to limitations of the human eye working under poor visibility conditions (full sun, shading by the beekeepers' hat and veil, sweat dripping into eyes, eyeglasses fogging up).

3. RESEARCH METHODS

From the study of previous research on bee colony and beehive, only one work doing on beehive detection using image processing. Due to this lack, this project will implement image processing techniques together with the segmentation algorithm, which is k-means to accurately detect the beehive and full honey pots as well. The k-means algorithm is selected as the cHT method did not provide accurate detection result on Kelulut beehive. Figure 1 shows two types of beehives, which is stingless and sting bee hive. The beehive of stingless bee, Kelulut is shown in Figure 1(a) and it has a variety possibility on its shape and size compared with the sting bee hives, which have a same diagonal shape and size as shown in Figure 1(b). Most of the researches [17]-[19] examined the beehive of the sting bee which have same diagonal shape and same size. With the same shape and size, it is become easier to segment the region of the beehive. From the review, none of the research focus on the Kelulut beehive shape as in Figure 1(a). It is quite challenging since the beehive have different shapes and sizes. To fill this gap, this work aims to accurately detect the full-honey pots in the Kelulut beehive using image processing method.

Figure 2 illustrated the flow chart of the proposed algorithm. It starts with the basic image pre-processing, including resize and sharpening applied to the raw image of Kelulut beehive. Then, the image will be converted to L*a*b color space to identify different colors in the beehive images. The pre-processed image will then be segmented and clustered using k-means algorithm and classification is made based on the count pixel in the clustered region. Details description for each step are explained in the following subtopics.

(a) (b)

Figure 1. Two types of beehives of stingless bee and sting bee, (a) Kelulut beehive with different shapes and sizes and (b) Sting bee hive with same diagonal shape and size

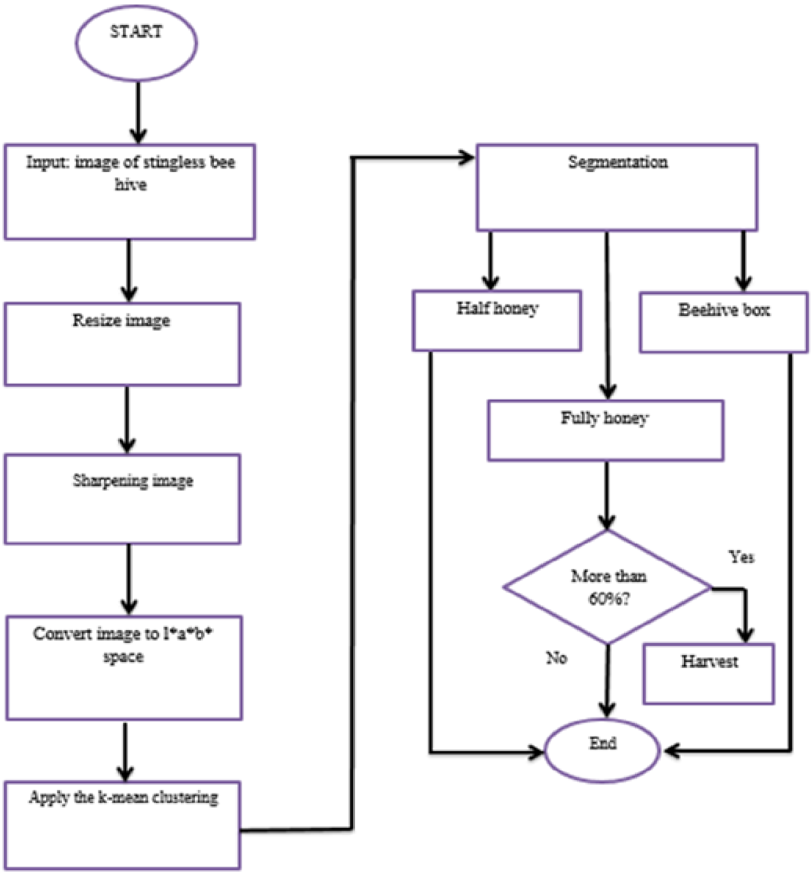


Figure 2. Flowchart for the proposed system

3.1. Image Acquisition

Data collection in a systematic approach can minimize the error that may happen during image processing. In this works, digital camera is used to capture images of Kelulut honeypot in the Kelulut farm as a data. The image is captured to estimate the amount of honey in the honeypots whether it full or not. The digital camera type Panasonic DMC-GF1 with 12.1 megapixel is used so that the high specifications of the camera able to capture good quality Kelulut beehive images. The data collection is done at one of the Kelulut bee farm which is located in Kuantan, Pahang. Figure 3 depicts the raw image that has been taken at the farm. Based on the image, it can be seen that the honey pots shape and size are different to each other and the presence of bridge structure connected the honey pots to each other.

3.2. Image processing

Then, the raw images go through pre-processing stage, whereby the color conversion and resizing image are done using the MATLAB software. The raw image is converted to L*a*b color space which have 3-axis color system with dimension L for lightness and a and b for the color dimensions. This method is done

to identify the different colors of the Kelulut beehive in the image. This step is supposed to help the segmentation process done by the k-means algorithm. The image then be resized to 400x400 to make easier processing. Sharpening the image increases the contrast between bright and dark regions so that the features can be extracted successfully. It likes a high pass filter applied to the image to filter out the low frequency, usually the noises and unwanted components. The following array in (1) is a kernel for a common high pass filter used to sharpen an image and being used for this work:

$$\begin{bmatrix} -1/9 & -1/9 & -1/9 \\ -1/9 & 1 & -1/9 \\ -1/9 & -1/9 & -1/9 \end{bmatrix} \tag{1}$$

Figure 4 shows the sharpened image using the kernel in (1). The big difference that can be seen is the lighter color of beehive box and the sharpen shape and color of honey pots.

Figure 3. Raw image of Kelulut Beehive

Figure 4. Sharpened image

3.3. Clustering

Clustering is a way to separate groups of objects. Instead of using cHT, k-means algorithm is applied in this work. K-means clustering treats each object as having a location in space. It finds partitions such that objects within each cluster are as close to each other as possible, and as far from objects in other clusters as possible. It requires specified number of clusters to be partitioned, which is ‘k’ and a distance metric to calculate how close two objects to each other. These steps are repeated until all data points are fixed to a specific cluster. While there are many distance measurements for basic k-means, this work focused on square Euclidean. Since the color information exists in the ‘a*b’ space, the objects are the pixels with ‘a’ and ‘b’ values. Basic K-means is a commonly used technique since it is typically computationally faster and produces tighter clusters than hierarchical clustering. Figure 5 illustrates the Kelulut beehive image that has been clustered using k-means method with k value equal to 3. Referring to Figure 2, the beehive image will be segmented into three cluster represented the three conditions, which are fully honey, half honey and beehive box segment. So, to classify the clustered beehive as shown in Figure 5, investigation on pixel distributions of the image is done to define which are full honeypots and half honeypots. According to the beekeeper, the honey is harvested when it contained 60% of honey in the beehive and it needs expert to do this task if using traditional method. By doing the traditional way, beekeepers need to closely check beehives one by one. It is a tedious way when the beekeepers need to deal with hundreds or thousands of beehives in their farm.

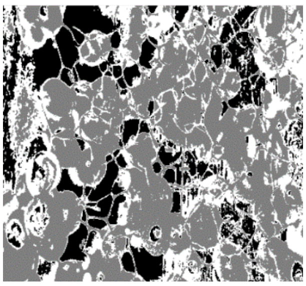


Figure 5. Clustered image

4. RESULT AND DISCUSSION

The experiment is done on 9 sample of images of Kelulut beehive due to the lack of Kelulut beehive available in the farm. The images are taken from the beehive house as shown in Figure 6. This is one of the beehive houses which is ready to be harvested according to the expert inspection. The house is made as a wooden box and is placed in the farm with variety of flowers surrounding it. The honey collected by the Kelulut bee from the variety of flowers will produce different taste of Kelulut honey.

4.1. Circle Detection using cHT Algorithm

In the previous work Liew *et al*. [23], cHT provides the good detection results, which is more than 80%. The algorithm able to detect the circles in the beehive for counting purpose. For the same goal, to detect the circle or shape of the honeypots, all the collected datasets are tested with cHT algorithm to determine whether it can detect the honey pots of Kelulut beehive or not. The result obtained from the experiment is cHT did not detect the honey pots accurately as its shapes are not absolutely in a circle shape as shown in Figure 7. This method needs us to determine the radius of the circle that are required, which seems unsuitable for Kelulut beehive because it has variety of shapes, and the honey pots are also overlapped to each other. To overcome this drawback, k-means clustering method has been choosing to detect the honey pots in the beehive.

Figure 6. Beehive house

Figure 7. Output of cHT algorithm

4.2. Honey pots detection using proposed method

4.2.1. L*a*b color space conversion

Figure 8 shows the image of the Kelulut beehive which has been converted to L*a*b color space. The L*a*b color space consists of a luminosity layer 'L', chromaticity-layer 'a', which indicates where the color falls along the red-green axis, and chromaticity-layer 'b', indicates where the color falls along the blue-yellow axis. The layers of the image are shown in Figure 8.

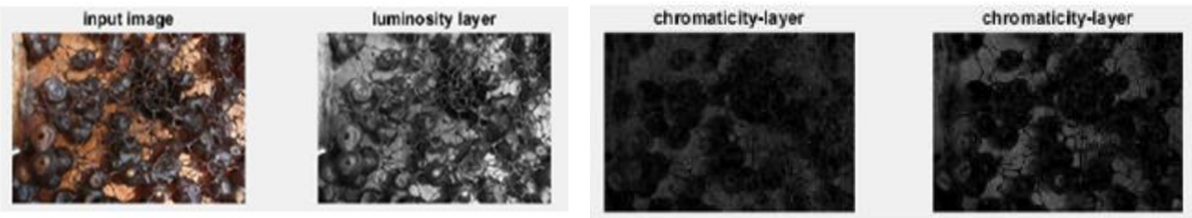
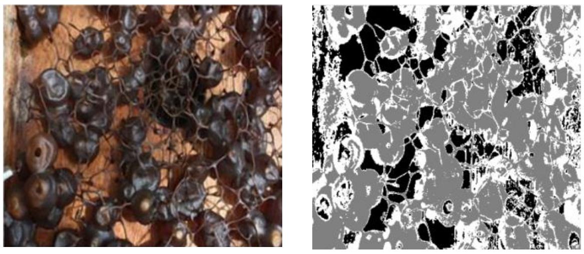


Figure 8. L*a*b color space images

4.2.2. Segmenting colors in 'ab' space using K-Means

Figure 9 shows one of the Kelulut beehive samples. The raw image of the beehive as shown in Figure 9(a) will be processed by using k-means method. The image in 'ab' space is clustered into three clusters using the Euclidean distance metric. The separation can be labelled as cluster index whereby index 1 represent the black region, index 2 represents the grey region and index 3 represent the white region as shown in Figure 9(b).

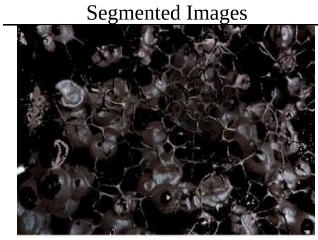
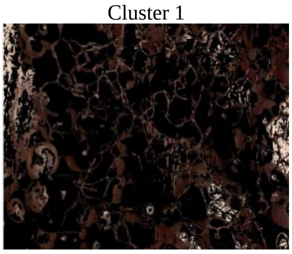
There are three images output from the segmentation process. The three images illustrate full honey, half honey and beehive box part. These three clusters have different numbers of pixel in each image. So, the number of pixels for each cluster will be used further in classification stage. The number of pixels of one of the Kelulut images is listed in the Table 1.



(a) (b)

Figure 9. One of the Kelulut beehive samples, (a) The raw image taken from the beehive house and (b) The segmented image using k-means

Table 1. Number of pixels for each cluster for dataset 1

Segmented Images	Number of Pixel
 Cluster 1	74701 pixels of 160000 pixel
 Cluster 2	51447 pixels of 160000 pixel
 Cluster 3	33272 pixels of 160000 pixel

4.2.3. Classifying clusters into full honey or half honey

The classification of the image is based on the color of the image which represent full honey, half honey and beehive box (beehive house). The clusters can be classified into three groups according to the number of pixels for each cluster as summarized in Table 2. Different image tested will result different values of pixels for each cluster. Table 2 summarized the clusters with its pixel numbers tested for Dataset 2. According to the results, in term of number of pixels, cluster 1 recorded the highest number of pixels, which represents the number of full honeypots is greater than the number of half honeypots and and also the area of the beehive house.

Table 2. Three clusters with its number of pixels for dataset 2

Image Classification	Number of Pixel
Cluster 1 (indicates full quantity of honey)	59809 pixels of 160000 pixel
Cluster 2 (indicates half of the honey quantity)	45033 pixels of 160000 pixel
Cluster 3 (indicates the Kelulut beehive house)	55161 pixels of 160000 pixel

The percentage of each cluster can be calculated using the number of pixels for each segmented image. The equation to calculate the percentage is shown as (2).

$$Percentage = \frac{\text{Number of pixel}}{\text{Total number of pixel}} \times 100\% \tag{2}$$

For example, if the pixel of full honey cluster is 59809 of 160000, then the percentage of the beehive contains full honey is 37.38%. 45033 of 160000 pixels is for half honey cluster, so the percentage of beehive, which is only contain half honey is 28.15%. So, the rest of the pixels are belonging to the Kelulut box pixels. For this case, the beehive only has about 37.38% of honey. The half honey is not being considered yet since it does not contain full honey in the honey pots. Figure 10 illustrates the summarized results for Kelulut beehive discussed above. 39% of the beehive are the full honey pots, while 28% are the half honey pots. The rest is the beehive box region. From this result, it can be said that all the beehive is still immature and need either weeks or months to be harvested. According to the beekeeper, the honey can be harvested when the quantity of honey is more than 60%. If the quantity of honey is less than 60%, the honey will not be harvested and let into the hive and wait for next inspection.

The graph in Figure 11 shows the percentages of Kelulut honey quantity for 9 different datasets. Instead of doing honey amount estimation by the beekeepers manually, it is easier to estimate the amount of the Kelulut honey using image processing method especially when dealing with hundreds or thousands of Kelulut beehive to be checked before harvesting. Based on these results, Data 1 contains more than 50% of honey and will be harvested when the honey amount percentage is reached to 60% and above while the others beehive house will be harvested later according to the percentage estimate by the proposed algorithm.

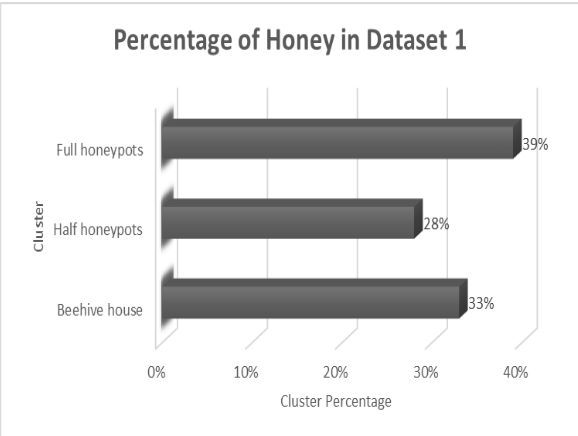


Figure 10. Kelulut honey percentage in Dataset 1

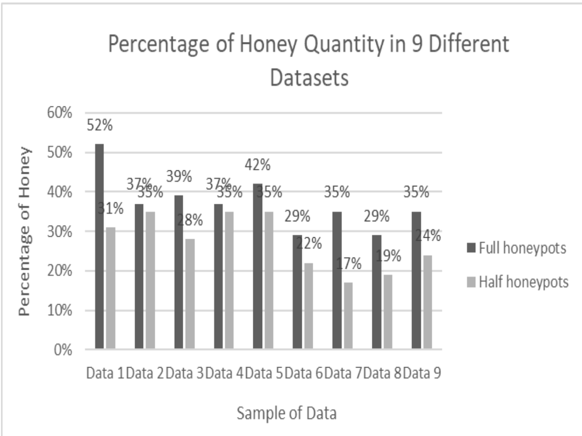


Figure 11. Percentages of honey in Kelulut hive

5. CONCLUSION

Nowadays, the advance in technology makes people live depends mostly on the automation system. The automated inspection and analysis technology is widely applied especially in quality control of industrial production. By understanding the same concepts used in the system, a new automated inspection algorithm is developed and been applied to Kelulut bee colony, which detect and estimate the amount of honey in the honeypots. The result shows that the proposed algorithm is good in detection and classifying the categories of the honey pots. According to the beekeeper expert, the results of honey estimation is quite similar with the manual checking and can be used to replace it to increase the productivity of honeybee food industry. For the future works, a full honey detection system will be built to improve the performance of the proposed framework.

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BIOGRAPHIES OF AUTHORS

Wan Nur Azhani W. Samsudin currently a senior lecturer in Faculty of Electrical and Electronics Engineering Technology, Universiti Malaysia Pahang, Malaysia. She received B.Eng in Electrical and Electronics Engineering from the Universiti Malaysia Pahang, Malaysia in 2007 and M.Sc in Computer Science from Universiti Malaya, Malaysia in 2010. She earns her PhD from Universiti Malaysia Pahang in Electrical Engineering in 2017. Her research interest is in computer and machine vision, image processing, deep learning, and surveillance system. Her latest research work has won in Creation, Innovation, Technology and Research Exposition (CITREX) 2021 and CITREX 2022. She can be contacted at email: nurazhani@ump.edu.my.

Mohd Harizan Zul obtained B.Sc (Manufacturing Engineering with Management) from Universiti Sains Malaysia, Malaysia in 2007 and M.Eng in Mechanical Engineering from Universiti Malaysia Pahang, Malaysia in 2017. He is currently a PhD candidate in Faculty of Mechanical and Automotive Engineering Technology, Universiti Malaysia Pahang. His research interest are in laser processing technology such as laser surface modification and laser micromaching. Before joining Universiti Malaysia Pahang, he has worked in various field, such as oil and gas equipment fabrication, manufacturing including production planning and control, scheduling, industrial engineering, manufacturing and production system, ergonomics and also TVET Education. He had received Award of Silver in International Stingless Bees Conference and Workshop with the innovation of Trigona Honey Solar Portable Vacuum in July 2017 and Silver Medal for Trigona Honey Portable Solar Vacuum Pump in International Innovation, Invention & Design Competition & Conference 2017 (ICON). He can be contacted at email: mohdharizanzul@gmail.com.

Mohd Zamri Ibrahim obtained both B.Eng and M.Eng in Electrical Engineering from Universiti Teknologi Malaysia, Malaysia, and a PhD in electrical and electronics engineering from Loughborough University, United Kingdom. His research interests are in the area of computer vision, internet of thing, embedded system programming, brain-computer interaction, image processing, intelligent system, and speech recognition. He is a senior lecturer at the Faculty of Electrical and Electronic Engineering Technology of University Malaysia Pahang, Malaysia. He had received more than 10 awards at national and international research exhibition and currently a principal investigator on TERAJU RM500K project on the Portable Vein Finder imaging device. Before joining Universiti Malaysia Pahang, He was a procurement engineer at Hewlett-Packard (HP) Malaysia where he worked as main technical interface with suppliers and HP design center (Vancouver and San Diego) to drive cost reduction, quality improvement and assurance of supply. He can be contacted at email: zamri@ump.edu.my.

Rohana Abdul Karim is a senior lecturer at Faculty of Electrical and Electronic Engineering Technology, Universiti Malaysia Pahang (UMP). She received a Bachelor Degree in Electrical Engineering from Universiti Teknologi Tun Hussein Onn (UTHM) in 2005 and a Master of Computer Science from Universiti Putra Malaysia in 2007. Her PhD from the National University of Malaysia (UKM) in 2017. Her research interests include biomedical engineering, computer vision, image processing, pattern recognition, video analysis and artificial intelligent techniques. Dr. Rohana research's work has been awarded the best paper award in International Conference and Exhibition of Women Engineers (ICEWE11') and International Conference on Electrical, Control and Computer Engineering (InECCE2017). Her research's work has been won several international and local innovation competitions including the International Invention, Innovation and Technology Exhibition (ITEX 2010), International Engineering Invention & Innovation Exhibition (i-envex 2011), BIOMALAYSIA 2011, International Festival of Innovation on Green Technology (i-finog 2018 and 2019). She can be contacted at email: rohanaak@ump.edu.my.